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An examination of the suitability of mechanical engineering education in relation to business profiles

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Abstract

This initiative is a contribution to the field's ongoing effort to enhance engineering education by including all relevant stakeholders. In partnership with various Moroccan businesses, it offers the key findings of a quantitative research on mechanical engineering education at the Higher National School of Electricity and Mechanics (École Nationale Supérieure d'Électricité et Mécanique - ENSEM). The subject and the chosen research approach were covered in the first part of the study. The second part included developing a survey instrument using the competence framework as a research model and outlining the hypotheses that would be evaluated. Then, a questionnaire that was created and pre-tested for the objectives of this investigation was completed by business executives from various industries. The findings demonstrate the benefits and drawbacks of ENSEM's mechanical engineering curriculum and outline the relationships between the different engineering abilities. The report concludes with a list of suggestions for dealing with the various problems noted and a description of the potential future directions for this study.

Keywords: adequacy, job-training, mechanical engineering, skills, education continuous improvement

1.0.Introduction

The labour market is significantly affected by globalisation because it generates new requirements and intense competition. Consequently, a range of highly professional vocations demand particular abilities (Terfous, 2006). Since the amount of acquisition differs between well qualified and poorly qualified engineers, the level of skills acquisition during first training continues to be important in the hiring process. Higher Schools nowadays compete fiercely with one another for the best training options available. Therefore, it is essential to continually enhance engineer training in order to provide students with the knowledge, skills, and social abilities (savoir, savoir-faire, savoir-être) that are useful in a variety of circumstances. Morocco increasingly emphasises the need of high-quality training as one of the nations undergoing unheard-of economic development via an Industrial Acceleration Plan. In this approach, it is proposed that the top industrialists articulate the skills needed in the labour market and that the necessary profiles be created for each ecosystem. Three factors necessitate the definition of the training-employment match: first, it pertains to recent graduates who have a variety of training profiles; second, it supports the idea that professional experience enhances one's skill set; and third, it concerns the notion that the competence attained through initial training can also be assimilated by the expertise related to the training's component parts (Vincens, 2005). Different trends and methods were noted in a prior assessment of the literature on the appropriate match between training and employment (Ait Haddouchane, Bakkali, Ajana, & Gassemi, 2017). Actually, there are three ways to look at this issue: the varying and evolving nature of internships throughout training, the recognition of professional experience, and ultimately, the entrepreneurial application of education and professional activity (Champy-Remoussenard, 2015). Comparing the training systems in other nations and then performing research to find the system that most closely matches the needs of company profiles may also be used to remedy

the issue (Charles, 2014). One of the main components of the competency-based approach is the alignment of training and employment. In order to generate graduates who meet the demands of the job market, it thus felt vital to adopt this technique to enhance training programmes (Deschryver, Charlier, & Fürbringer, 2011). Another movement connects the problem of the training-employment fit to the question of certificate quality uncertainty and the amount of time required to determine a laureate's degree of skill development. This led to recommendations for the introduction of competitive exams for hiring and the expansion of probationary periods, among other things (Felouzis, 2008). The competency-based approach was used in this study to address this issue. Such a strategy guarantees effectiveness and relevance at the level of curriculum while highlighting both the cognitive and contemporary social concerns. It promotes fairness and makes everyone aware of their obligations, particularly the kids (Roegiers, 2016). By expressing the need for knowledge, the understanding of competencies, the demand for more suitable evaluation methods, and a re-acquisition of the training course by the student, the competency-based approach also guarantees a varied usage in the field of training design (Chauvigné, & Coulet, 2010). Although it is commonly used, the word "competency" has been defined by several writers and is interpreted in various ways (Aubret, 1993; LeBoterf, 1994; Zarifian, 1999; Tardif, 2006). Numerous arguments and complaints were raised about this. Nevertheless, the elements of a competence might be mutually agreed upon to fall into the following seven categories:

• a behavioural awareness; • a specific grounding in situational realities

A tight connection to the many facets of knowledge; the development of disciplinary and cross-disciplinary abilities; the improvement of both individual and group competences.

• a capacity for reflection; • the development of some measure of autonomy.

The competence framework that serves as the foundation for the pedagogical portion of the work serves as the interface that enables the transfer from the world of work to the world of training. In line with human resources management, training, and assessment, the framework establishes a connection between the demands of the profession and the people (Roegiers, 2010).

The responsibilities of the competence framework were developed by Raisky and Cros (2010) based on the professional and academic components. The many roles stated are shown in Flowchart 1.

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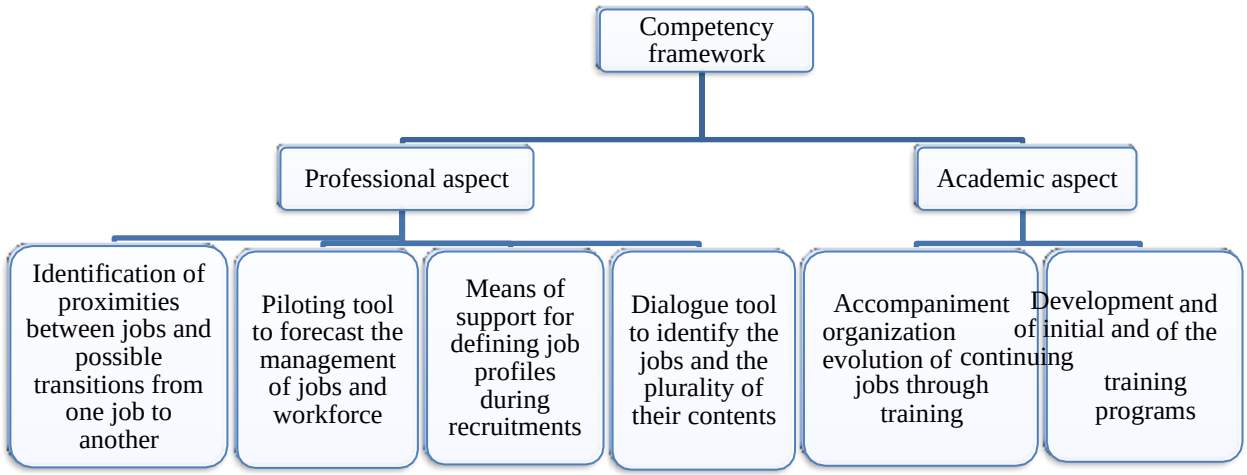

The Bologna Process, a platform for inter-university collaboration, cross-cultural dialogue, and the affirmation of a European model, was chosen by the Moroccan government in 2003 to restructure its higher education system. The goal is to provide a uniform framework for higher education and harmonise the processes that control it (the "LMD" or "graduate, post-graduate, and doctoral system") (Ghouati, 2010; Gardelle, Cardona Gil, Benguerna, Bolat, & Naran, 2017).

In 2007, Engineering Schools in Morocco started putting the specialty system into place. They lack competence frameworks, but they have accreditation descriptors that list the training programmes offered and are evaluated every four years. Since the ultimate purpose of the training is to prepare the learner to be able to carry out the activities of the trade, competence frameworks are indeed required since they serve as both a reference to be followed for the construction of training materials and as a final target to be accomplished.

In Morocco, engineering science training lasts three years and is preceded by two years of prerequisite coursework. Students take competitive entry exams, allowing their ranking to determine which engineering schools they are sent to.

In order to give Morocco a new boost by enhancing its economic resilience, solidifying its position among the developing nations of America, Europe, the Middle East, and Africa, and moving in the direction of a more secure economic path, the National Industrial Acceleration Plan 2014-2020 was created in 2014. When it meets the job profiles needed by the market, training is essential to the project's success. It is a way to draw domestic and foreign investors and take part in the development and competitiveness of businesses (MIICEN, 2014). Engineers are among the crucial human resources needed to satisfy the demands of many economic sectors.

This paper emphasises how engineers are trained at ENSEM to carry out a qualitative adequacy analysis. Mechanical engineering, electrical engineering, computer engineering, and industrial engineering are the four engineering disciplines that this institution offers academic degrees in.

The goal of this study is to highlight the qualitative alignment between the education and employment of engineers, who are one of the most important human resources responsible for determining and addressing the demands of many economic sectors. The research approach used for this examination, which is based on the competence framework of the Swiss Federal Institute of Technology in Lausanne (École Polytechnique Fédérale de Lausanne - EPFL) as a research model, is presented first in this project. The remainder of the paper goes on to describe every step of the research project, including the listing of hypotheses, the description of the sample (the respondents to the questionnaire), the analysis of the statistical findings, and finally the formulation of some initial suggestions that will be covered in a subsequent analysis.

2.0.Issues and Research Methodology

Given the vast and varied tasks that engineers are given, they are among the essential human resources that help a firm develop. Gardelle, Cardona Gil, Benguerna, Bolat, and Naran (2017) state that engineering education is seen as being very crucial for Morocco, a country that

depends on industrial growth and the knowledge economy. There are several efforts being taken by educators, programme directors, and leaders at the highest levels to think and act for the qualitative and quantitative advancement of engineering education while looking for inspiration outside. 2017: page 208 (Gardelle, Cardona Gil, Benguerna, Bolat, & Naran) The examination of the current state of new graduates' skill acquisition levels serves as the introduction to this research article. The goal is to identify the skills Moroccan engineers should possess in order to better fulfil the demands of the Moroccan labour market and, as a result, improve the quality of engineer education (MIICEN, 2014). Within the many training programmes, there are many different ways to address the topic of how training and employment might be matched. Important questions, which may be technical and managerial in nature, are generated by the surroundings of training or the labour market. At this point, the goal is to identify the faulty query that has to be examined: How might we enhance the ENSEM engineers' training so that they possess the abilities demanded by the job market? Since it is of a causal and explanatory character, the training-employment fit is an issue that cannot be directly addressed. The following two broad research issues must be addressed:

Does the education of an ENSEM engineer1 qualitatively satisfy the demands of the job market?

• General Research Question 2: What qualities define an ENSEM engineer? And what skills need to be developed?

This study's goals are to highlight the advantages and disadvantages of ENSEM's mechanical engineering curriculum in contrast to industry standards and to identify relationships among the different engineering abilities.

Given the large number of its laureates who satisfy the demands of Moroccan industry and its economy, mechanical engineering is chosen since it represents a crucial sector for ENSEM. Indeed, from 75 in 2013 to 89 in 2017, there were graduates in this field, indicating a rise in the proportion of all graduates from 37% to 41%. The goal is to enhance these graduates' training for a better training-employment fit while also increasing their employability rate. As a result, the first goal of this inquiry is to fully immerse all parties in the context of Moroccan engineers' training and workplaces. A field research must be carried out to measure the disparity between company profiles and training programmes in terms of skills in order to more clearly explain the training-job match issue. The aforementioned field research covers a number of stakeholders, including industrialists and engineers who have just entered the workforce. Next, we'll provide recommendations for action plans at the level of engineering science training programmes. The constructivist paradigm was selected to respond to our study questions in light of this methodology. In fact, constructivism compares the subject of study to a project of building and comprehending a reality that is understood and described; such a project is reliant on stakeholders, researchers, and their action plans continually (Grenier, & Pauget, 2007).

The research approach used in this study has been shown to be sufficient for obtaining objective information using the scientific method. The technique chosen helps to better understand the phenomena under investigation and is suitable for the study's object and research objectives. In the present instance, a quantitative technique has been used as a result of an explanatory piece of study. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by John W. Creswell (2013) indicates that this approach is used when examining an issue having causative and explanatory components and when there are measurable variables specified in a hypothesis (Creswell, 2013). The selection of the proper research model was the

main responsibility at this stage. The research hypotheses that will be looked at in this study were then presented. Following that, each component of the questionnaire that had been evaluated on manufacturers was meticulously crafted. To be able to respond to the aforementioned study questions, data were gathered and evaluated after the participants were chosen to form the sample.

3.0.Construction of the Survey Instrument

3.1.Research Model

The foundation of this study is the mechanical engineering competence framework from the École Polytechnique Fédérale de Lausanne (EPFL), a Swiss Federal Institute of Technology. Following a comprehensive examination of Francophone mechanical engineering competence frameworks, this reference frame was chosen (Ait haddouchane, Faraj, Bakkali, & Ajana, 2016). The following facts led to this decision: the resemblance between the Moroccan and Francophone training systems; the need to maintain the homogeneity of the sample of competence frameworks. The EFPL competence framework is distinguished by its clarity and simplicity. Additionally, in addition to particular features that are addressed at the level of learning outcomes, it has a generic and so transferable element. Additionally, the study plan was developed using simple axes that were similar to Bloom's taxonomy. The final paper includes information on each competence framework component as well as the connections that exist between them. As a result, the framework may be identified by: The hierarchy of macro-competencies and their constituent parts: it includes a restricted number of components, ranging from three to five, and a varied description of evaluable, interconnected talents. Formatting: It compiles the components into a summary table in a logical arrangement. The design process is thoroughly described and is based on a competency-based approach, according to the description of the elaboration methodology. Additionally, the many parties engaged in its execution are listed, including the managers who consented to participate in the Delphi study as well as the mechanical engineering section instructors, engineers, guidance counsellors, and managers. Identification of training circumstances: Examples of training situations are suggested for the development of competences for each component. The list includes actual projects, lectures on analytical methods, and training on particular instruments. Different professional circumstances that a mechanical engineer may encounter are listed, along with the necessary abilities that must be proven in each circumstance. Identification of essential ideas: We identify the knowledge, skill, and social abilities that educators should demand of students in accordance with clearly stated mastery criteria. Several of the studies listed utilised the EPFL competence framework for mechanical engineering and the study plan as references.

3.2.Research Hypotheses

According to Section 4.2 of this article, the five abilities in the selected research model are distinct, quantifiable, and interconnected. They also have a small number of components, ranging from three to five. By establishing the following value rating scale, the objective is to achieve a thorough appraisal of competence components on two levels, the level of significance and the level of acquisition: Using the EPFL's mechanical engineering skills framework, the questionnaire was created. Information on the respondent, the engineer, and an assessment were all included in this instrument. Single-choice, closed-ended questions made up the first section. These questions asked about the respondent's role and degree of seniority within the organisation, as well as his level of education, the company's branch and sector, etc. They also asked about the engineer's age, sex, and industry. Five competences, broken down into

components, made up the second section. We used the Likert scale to design this part and asked respondents to indicate the evaluation that best represented their opinion. In our scenario, two scales were established for each component to assess both the engineer's level of acquisition and the component's level of significance. The Likert scale was used to determine the degree of significance, with 4 modalities for "extremely important," "important," "somewhat important," and "unimportant," and 3 modalities for "properly acquired," "moderately acquired," and "not acquired" for the level of acquisition. In order to save the responder the trouble of selecting the easiest response, which would have skewed the findings, the neutral modality in the centre of the scale was excluded. Several safety measures were considered while creating the questionnaire: An explanation of the questionnaire's background and its significance for the respondent's interest in the survey were provided on the first page of the questionnaire. Additionally, it provided a thorough characterization of the two suggested Likert scales—the significance level and the skill acquisition level. It was stated that the questionnaire had to be completed objectively since the responses were to be given in a professional setting. There were many questions on the questionnaire. In order to prevent responders from becoming discouraged, it was split into five macro-skills that comprised the many elements listed in a table.

3.3Pre-Test of the Questionnaire

The questionnaire underwent a pre-testing process in collaboration with ten industrials holding various positions to determine its viability and relevance, including the Director of the Consortium of Moroccan Aeronautical and Spatial Industries, the Head of Assessment and Selection Service, Industrialization Managers, Human Resources Managers, Automation Manager, Quality Managers, and Maintenance Manager. This pre-test enabled some changes to be made to the questionnaire, including the redefinition of the Likert scale for the acquisition level, the elimination of some terms related to the engineering of training that were occasionally difficult for industrialists to understand, and the rearranging of some of the questions.

4.0.Results

4.1.The Sample

The current study concentrated on the Mechanical Engineering Department at ENSEM, which has four domains: Industrial Processes and Plastics (Procédés Industriels et Plasturgie - PIP), Mechanical Conception and Integrated Production (Conception Mécanique et Production Intégrée), and Quality Maintenance and Industrial Safety (Qualité Maintenance et Sécurité Industrielle - QMSI). Only 51 of the 210 businessmen who were contacted returned the whole questionnaire. Each of them employed an engineer who had just received their degree from ENSEM. 90.2% of industrialists were men, compared to 9.8% of women, making up the majority. Their degree of schooling is shown in It is mentioned that 84% of those surveyed had a master's degree (high school diploma plus five years of college), and the majority were engineers working in various sectors. According to the accompanying pie chart, the 51 industrialists were engaged in a variety of mechanical engineering-related fields, including the Engineering Office, Mechanical and Industrial Engineering, and the Automotive Industry. shows the percentage distribution of mechanical engineers throughout the various Moroccan industrial sectors. 86.2% of these businesses were in the private sector, 11.8% were in the semi-public sector, and just 2% were in the public sector. Thus, the private sector was where most ENSEM engineers were hired. These business owners were requested to respond to the questionnaire created to evaluate engineering ENSEM graduates from classes between 2013

and 2017. These seminars were specifically aimed towards recently graduated trainees from the same training programme; their selection was not haphazard. The businessmen were requested to seal the questionnaires they filled out in order to ensure the validity of the data gathered. The engineers ranged in age from 22 to 28 years old, and 78.4% of them were men, with just 21.6% of them being women. The dominance of males in the mechanical industry explains this. Compared to the other branches, the PIP branch's participation percentage was low. It is important to note that PIP is a recent addition to the ENSEM.

4.2.Analysis of Results

The examination of the information gathered from 51 industry executives produced the conclusions that are now being presented. One freshly minted mechanical engineer worked under each of these businessmen. As a result, each industrialist thought to ask their just graduated engineer to fill out the questionnaire. SPSS (Statistical Package for the Social Sciences), a software programme used in statistical analysis of all types of data and the most appropriate for research purposes, was utilised to analyse the data gathered in this survey. enumerate the numerous elements that make up the five competences of ENSEM engineers and their relative relevance and degree of acquisition. demonstrates the relative relevance and degree of acquisition of the key elements that make up Competency 1 for ENSEM engineers. It should be highlighted that the organisation placed a high priority on each component of Competency 1. In terms of acquisition level, 62.7% found it challenging to comprehend and manage two-way communication in both French and English (C1.2). Additionally, there is still need for progress in the area of comprehending the professional, technical, ecological, and economic environment. On the other hand, the ENSEM mechanical engineer was distinguished by his ability to learn new things, hone new abilities, and impart the many parts of technical knowledge. demonstrates the outcomes obtained after studying the information pertaining to Competency 2. The competence components C2.1, C2.2, and C2.4 were judged to be of the greatest relevance, whereas component C2.3 was only somewhat significant in relation to the industrial market. Regarding the degree of acquisition, 53% of respondents felt that engineers struggle to choose the tools and methods of analysis that are most suited to the intended goals and available resources. Additionally, 58.8% of ENSEM engineers had difficulties evaluating and presenting modelling and analytic findings, and 78.4% of them were unable to assess complex, dynamic, and ambiguous situations successfully. However, identifying the analysis aim (C2.1) was a component that 64,7% of ENSEM engineers had correctly mastered. It was determined by analysing the response data for Competency 3 that all of its components were, for the most part, of utmost importance. Additionally, the mechanical engineers of ENSEM had a weakness when it came to incorporating creativity, efficiency, and sustainability into the design and implementation of solutions. Additionally, creating a detail remained a skill that needed to be developed for mastery. However, 58.8% of the participants in the poll said that they had correctly learnt the component of evaluating the alternative solutions to arrive at the most appropriate. The ENSEM mechanical engineer also showed that he could create project scope statements. It was discovered that every element of Competency 4 was crucial. One of the essentials for engineers, the project management competence component (C4.2), was poorly understood by 70.5% of those polled. The findings also showed that 51% of the questioned engineers had successfully mastered the qualities of autonomy and self-direction. The findings of the replies on Competency 5 are shown in Figure 8. The five elements of this skill were shown to be crucial for businesses. Staff management, professional career, collaborative work, and critical thinking (C5.3 and C5.5) needed reinforcement in terms of training due to the modest level of acquisition they had received from more than half of the participants in the survey. However, the ENSEM Mechanical Engineers had a high level of

mastery in the skills of dedication, labour, taking responsibility for one's actions, and job completion with rigour and accuracy (C5.1, C5.2, and C5.4). Note: The average score, standard deviation, and variance were determined for each of the five competencies' components' significance level and acquisition level. It was discovered that all of the standard deviation values were low amplitude and less than half the averages. As a result, the variance's values were relatively low. The survey's participants' replies were also quite similar, which explains their homogeneity.

4.3.Recapitulation

The figure shown summarises the findings for each competence and is instructive. It displays in percentage terms the various relevance levels for the various capabilities, followed by the various stages of acquisition. It has been established that all skills are essential for a mechanical engineer. For all skills except for Competency 5, it can be shown that the total of the percentages of the two modalities "moderately acquired" and "not acquired" surpasses 50%. Additionally, it is interesting that Competencies 1, 3, and 5 and Competencies 2 and 4 have proportionately different acquisition levels. The next step is to analyse the correlations between the various components to learn more about how they are related to one another.

4.4.Analysis of Correlations

It was judged practicable to utilise Pearson's Correlation Coefficient test with a 0.05 significance threshold to infer the presence of a relationship between the components of each skill in terms of their degree of acquisition by the laureate. This method highlights the findings that show a strong correlation between the components, which is shown by a correlation coefficient r of more than 0.5 and a p-value for the slope test of less than 0.05. (Cohen, 1988). One can determine if there is a linear connection between two variables using Pearson's correlation coefficient (Cohen, 1988). According to the findings of the Pearson's Correlation Test, there is a linear relationship between being able to mobilise basic technical knowledge, being a leader, being dedicated and putting in hard effort, behaving morally and responsibly, and being able to produce project scope statements. In truth, it takes an understanding of how to listen to, analyse, and present the finest suggestions to the client in order to produce a scope statement. The recommended product must also adhere to the numerous criteria, as stated in the scope statement. Writing pertinent project scope statements consequently requires the resolution of issues and conundrums based on a decision-making process and the assessment of options in accordance with standards. This research also supports the presence of a beneficial relationship between the interpretation of the findings of analyses, modelling, and professional growth, on the one hand, and the selection of analytical tools that are appropriate for goals and resources, on the other. This outcome is the consequence of the engineer's attention to the precise and affordable tools that may be used. The constant assessment of demands and ongoing investigation of the means of development enable the engineer to expand his knowledge of the many current approaches. So, above productivity and technology use, the choice of technique and the capacity to evaluate and synthesise the produced data take precedence. In fact, the earlier parts enable decision-making based on analysis and modelling goals. Professional development component C5.5 is connected to a number of other components, including managing projects and people, working together, interpreting and analysing various findings, and acting responsibly. This outcome is noteworthy since C5.5, which deals with the continual development of various abilities obtained via self-evaluation to foster the growth of a critical mind, touches on both the pursuit of professional advancement and the development of a critical mind. Being dedicated, working hard, and behaving morally

and responsibly are all components of managing projects. It is true that managing a project calls for people to adopt new attitudes and engage in a spirit of dedication and participation.

4.5.Confirmation or Rejection of Hypotheses

Calculating the average of the score averages for the elements that make up each skill is the job in order to confirm the original hypothesis. According on the results, the original hypothesis might either be confirmed or disproved. It is clear that in order for mechanical engineers to work for Moroccan businesses, they must possess the five competences. Additionally, changes should be made to allow ENSEM mechanical engineers to successfully acquire these skills.

5.0.Conclusion and Perspectives

The goal of this inquiry was to define and defend the approach that was chosen, which was based on a quantitative analysis. This study asked businessmen from several business sectors about their opinions on the mechanical engineering curriculum at ENSEM. This essay explains why the competence framework for mechanical engineering at EPFL was chosen as the research model on which the study was based. This methodology enabled for the pre-testing of the industrialist questionnaire to be changed. The SPSS software's descriptive statistics and linear correlation were used to analyse the acquired data. The findings made it possible for this study to emphasise the cross-cutting strengths and weaknesses at the level of technical abilities as well as to determine the relationships between the different elements. It was feasible to emphasise that all the indicated capabilities were judged vital in the business profile of an engineer after conducting the study of the relevance and acquisition levels of the competencies necessary in the industrial environment. In this regard, there is reason to think that it is essential to provide some suggestions in order to solve the numerous flaws in the parts of skills that are not learned or are gained only to a modest degree. The ENSEM must encourage engineering students to prepare presentations on mechanical engineering topics that they may offer in seminars, to read and discuss the content of scientific and professional articles, etc. in order to enhance oral and written communication skills. To reach the mastery level of theoretical, digital, and empirical analysis methodologies, seminars should also be conducted that revolve around analysis technologies and concentrate instruction on certain tools. Additionally, it is essential to build planning for the completion of projects that call for the capacity to design, simulate, and execute a cutting-edge set of solutions, as well as promoting the creation of reports that summarised analyses. Additionally, there is a need to concentrate on setting up reverse engineering workshops, excursions to different industrial facilities, and encouraging engineering students to take part in a variety of projects and tasks in order to enhance their individual project portfolios and advance their skills. To get particular and often busy professional leaders to respond to approximately 34 questions was the major problem of this questionnaire in terms of the system that needed to be set up for the gathering of the required data. The decision was made to either go and personally deliver the questionnaire to the ENSEM laureate engineers in person or call them to gather the email addresses of their bosses. We chose this strategy because it enabled us to preserve traceability while also customising the questionnaire by include the name of the laureate we wanted to examine. The small sample size was one of the study's shortcomings. To correct this, a qualitative research with semi-directive interviews with academics and industry managers would need to be conducted in order to enhance the findings. The next stage is to verify the findings from the industrialists' semi-structured interviews. Later, it becomes vital to include other parties in the research, such instructors and directors, so they may assist. This would then lead to the recommendation of action plans to enhance ENSEM's mechanical

engineering training programmes by using a variety of high-quality tools and determining the viability of those plans. Such initiatives are crucial for the long-term enhancement of the quality of engineering science education, particularly in light of the world's growing reliance on technology.

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